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AUTHOR	Kirmse, Dale W.; Manyimo, Steve B.
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ABSTRACT

This executive summary presents a brief analysis of findings and recommendations. The concept of the Integrated Utility System (IUS) is to consider the interaction and mutual support of five utility subsystems needed by a campus complex of buildings. The subsystems are: (1) Electric power service; (2) Heating - ventilating - air conditioning and hot water service; (3) Solid waste handling; (4) Liquid waste handling; and (5) Potable water service. The IUS concept seeks optimum system performance. An IUS feasibility study at the University of Florida is summarized. (Author/MR)

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Executive Summary
October 1976

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Integrated Utility Systems

Feasibility Study and Conceptual Design at the University of Florida

SE 025 994

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WASHINGTON, D.C. 20201

INTEGRATED UTILITY SYSTEMS

IUS

FEASIBILITY STUDY AND CONCEPTUAL DESIGN
AT THE UNIVERSITY OF FLORIDA

EXECUTIVE SUMMARY

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

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Office of Facilities Engineering and
Property Management - Planning and Development

PREFACE

This Executive Summary presents a brief of the analysis, findings, and recommendations contained in the report, "Integrated Utility Systems - Feasibility and Conceptual Design at the University of Florida."

The report is the result of a cooperative effort by the University utility managers, the HEW Project Office and the HEW Consultant Contractor, Reynolds, Smith and Hills, Architects, Engineers and Planners, Inc., of Jacksonville, Florida. The involvement of the HEW Office of Facilities Engineering and Property Management is a consequence of its mission of providing architectural and engineering consultant services to the medical and higher education community, and, the University's agreement to collaborate with the HEW team in performing the feasibility study on the Gainesville campus.

The sponsor of the HEW effort was the Experimental Technology Incentives Program (ETIP) Office of the Department of Commerce, National Bureau of Standards. The ETIP involvement is particularly innovative. This program seeks through very modest fiscal assistance to examine and experiment with Government policies and practices in order to:

- Identify and remove Government related barriers to technological change in the private sector; and
- Correct inherent market imperfections that impede the innovation process.

The objective of the project is to demonstrate that the Integrated Utility Systems (IUS) concept can conserve energy and potable water, effect cost of energy savings, and improve pollution control.

The architectural-engineering hypothesis that leads to the formulation of this objective is based on these considerations:

- Historically, utility services required by a community of buildings developed as separate entities over time beginning with Roman aqueducts and evolving to electric power, gas, and other utility services in the late nineteenth century.

- Changes could be made in perception, custom and law which would reduce constraints on the view that combining those services can produce benefits in an era of increasing costs of capital, fuel, and potable water, and decreasing availability of these resources.

- There are clear technological opportunities to save costs, save energy, and conserve potable water as well as improve solid and liquid waste handling, if the non-technical constraints can be logically accommodated.

The technological approaches within the IUS concept are not new; pieces and parts of the concept have been in use for many decades. Why did the concept not prosper? Primarily because the shortage of petroleum and natural gas fuels was not expressed in very high fuel costs until recently.

The Federal effort at the University of Florida, and at Central Michigan University in Mount Pleasant seeks to dramatize and demonstrate that: With a very modest effort, in collaboration with enlightened institutional executives and managers, straight-forward problem solving methods and sound architectural-engineering practice can point the way to significant cost and environmental benefits.

What contribution and impact can a successful IUS in Florida and Michigan produce? It is to be expected that many health and education institutions will be interested in the recommendations made to the University of Florida and Central Michigan University.

The Department of Housing and Urban Development is working on a similar project for residential communities; the Energy Research and Development Administration is proceeding with an "Integrated Community Energy System (ICES), Grid Connected." These latter efforts have different strategies, but the entire effort has to do with the integration of systems for energy conservation.

ACKNOWLEDGEMENTS

A number of individuals and organizations have contributed to the project effort. The support and interest of these key executives was especially important: Dr. Robert Q. Marston, President of the University of Florida, Dr. Jordan Lewis, Director of the Experimental Technology Incentives Program (ETIP), and Gerrit D. Fremouw, P.E., Deputy Assistant Secretary for Facilities Engineering and Property Management, Department of Health, Education, and Welfare.

UNIVERSITY OF FLORIDA

Dr. Joseph H. Stafford, Vice Chancellor of Planning for the Board of Regents of the Florida State University System
Calvin C. Greene, Director of Physical Plant
D. Neil Webb, Associate Director, Planning and Analysis Division

EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM, DEPARTMENT OF COMMERCE - NBS

Richard Penn, Chief, Special Projects and Project Advisor
Jean Taylor, Systems Planning Corporation

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Robert Blake, P.E., Director of Planning and Development
Donald Boyle, P.E., AIA, Chief of Development Division and Project Officer
Dr. Max Novinsky, P.E.

HEW UTILITIES CONSULTANT
Stefan L. Geiringer, P.E., Paul Geiringer Associates

HEW CONSULTANT CONTRACTOR
Reynolds, Smith, and Hills, Inc.
Ben J. Bucalo, Contract Officer
Dr. Edwin F. Coxe, Project Officer
Dr. Dale Kirmse, Project Manager
Steve Manyimo, Project Engineer

A INTRODUCTION

The concept of the Integrated Utility System (IUS) is to consider the interaction and mutual support of five utility subsystems needed by a campus complex of buildings. The subsystems are: (1) Electric Power Service; (2) Heating-Ventilating-Air Conditioning and Hot Water Service; (3) Solid Waste Handling; (4) Liquid Waste Handling; and (5) Potable Water Service. "Integration" of the subsystems is a design approach that seeks to establish those aspects of each subsystem that can assist the overall system performance. Said another way, the IUS concept seeks optimum system performance. By and large, current institutional utilities subsystems are treated as separate entities.

The essence of an energy saving and financially feasible IUS is on-site generation of all or part of the needed electric power service and utilization on-site of the cast-off heat normally lost at a large remote power station and also the energy normally lost in transmission to the institution. In addition, IUS considers utilization of the heat values derived from solid waste incinerated on-site.

Within the context of a specific site, liquid waste handling can include extraction of the liquid portion of the waste and purification to standards that would permit the final effluent to be discharged into the stream system. In addition, the final effluent can be used for such purposes as plant process water and irrigation in order to reduce the demand for potable water. The sterile ash remaining from the solid waste incineration operation can be placed in a landfill. There are potential uses for the solids resulting from the liquid waste handling operation, such as fertilizer.

It is conceptually feasible for an IUS to provide self sufficiency for utility services within the state-of-the-art of proven technology. Furthermore, the system can be designed to accommodate the addition of heat and power from other services, such as solar energy when technological advances so warrant.

In this application of the IUS concept the environmental considerations include:

- Reduction of solid waste by incineration to 5% of its original volume, and removal of the sterile ash to a landfill, obviously reducing the volume to be accommodated in the landfill. The ash will not contribute to ground water pollution. Costs of installing and operating this subsystem were included before estimating the net savings or credits.

- Reduction of the potable water demand through utilization of some of the liquid waste effluent for plant process water and irrigation. Costs for this aspect of the integration are small and were not included.

- Pollution control devices to meet local and national standards, and the costs of these devices and their operation and maintenance were included before making estimates of net savings.

It is to be emphasized that IUS concept applications are "site-specific" or custom designed to a specific institutional situation.

Finally, the IUS installation recommended provides to the individual campus buildings utility services responsive to present demands. This means that additional energy conserving actions that may be implemented within the buildings will provide additional cost of energy savings associated with the proposed IUS.

B RECOMMENDATION

As a result of the findings and analysis contained in the report, "Integrated Utility Systems (IUS), Feasibility Study and Conceptual Design at the University of Florida," the following recommendation is made to install an IUS on the Gainesville campus.

Proceed now to budget, design, and install a 12.5 megawatt thermal electrical generating plant plus a 25 tons per day, or a 75 tons per day, solid waste incineration plant. In support of that effort act promptly to modify the air conditioning expansion program so that 5,900 tons of air conditioning is provided by absorption chillers rather than electric motor driven chillers as now planned. The thermal electric plant would consist of two multi-fuel boilers (coal, oil, or gas) and two steam driven 6.25 megawatt variable extraction turbine generators. Part of the existing steam distribution system would be converted to a "Low Temperature Hot Water" heat distribution system. The existing heating plant should be retained for back-up reserve. The new power plant and solid waste incinerators would be located nearby and associated with the existing heating plant.

The new equipment and existing plant modifications will provide 85% of the electric power requirements for the University, and 100% of the space heating, air conditioning and hot water service requirements. The balance of the electric power needed by the University would be supplied from its present sources on the utility electric power grid. Improved pollution control will result for the University and surrounding community.

The annual energy cost savings beginning in 1981 when the plant would start up is estimated at 41-44% of the expected annual cost of energy in 1981 if the University were to continue in its present mode of operation. (See also Figure 1.) That, coupled with an interest rate of return on the investment of 23% and a pay-back period of less than 5 years makes it a very attractive option.

The recommended option costs and benefit details are presented on Table 1. Table 2 and Table 3 present for budget purposes the investment disbursement costs inflated to the pertinent fiscal year, for the 12.5 megawatt plant, plus a 25 tons per day or a 75 tons per day solid waste plant.

C INCREMENTAL ALTERNATIVE RECOMMENDATION

As an alternative to the foregoing recommendation, an incremental installation program is presented on Table 4. This breaks the recommended IUS into two phases. Phase I, which is approximately one half of the recommened IUS, would be fully operational and would yield roughly half of the benefits if Phase II were never built. In that case the interest rate of return on the investment would be 22.4 percent and the payback period would be 5 years.

The purpose of the incrementation as displayed on Table 4 is to show what fiscal year expenditures would be if the project were phased. Although Phase II is only slipped one year, it would be possible to slip it any reasonable period of time. The penalty, of course, would be in the escalation of construction costs and more significantly in the loss of about $2,000,000 per year in operational savings.

D OPTIONS FOR SOLID WASTE INCINERATION

The following solid waste incineration options are feasible when made part of the proposed IUS. Waste incinerators are now available that meet air pollution standards and deliver steam useful for reducing other fuel demands. The incinerators can be enclosed to preserve an attractive external appearance; the operation is on an 8-hour, 5 day a week schedule, and does not require highly skilled operators.

The smaller option is based on the University generated solid waste at a rate of 25 tons per day. The larger option includes the University and the City of Gainesville commercial dry waste at a rate of 75 tons per day. Truck traffic would range from 5 truck loads per day to about 15 truck loads per day. The residue of the solid waste is a sterile ash of about 5% of the volume of the waste input, and the ash would be trucked to a land fill. Main economic features are (from Table 1):

	University	City & University
o Volume (tons/day)	25	75
o Capital Cost	$729,000	$2,066,000
o Annual Operating Credits or Savings	$183,000	$333,000

The larger volume option would require discussions with the City of Gainesville in order to assure a supply of solid waste and a mutually beneficial agreement.

E CONSIDERATIONS FOR MAKING THE IUS DECISION

In the main body of the Report detailed analyses of the current energy posture of the University and the future possibilities are provided. A summary of the basis for making the Recommendation is presented.

The University utility managers and the IUS Feasibility Study team - the HEW Project Office, the ETIP Advisor, and the Consultant contractor - have together endeavored to present a professional technological appraisal of the University situation. The University executives and State of Florida public officials will want to review the Recommendation and challenge the basis for the Recommendation in order to make their decision.

The following assumptions have been incorporated into the Study Report:

Item	Assumption
• Natural gas available in 1981 at an attractive relative cost	Not probable
• Fuel availability 1981, burned in the present plant if IUS is not adopted	Fuel Oil
• General inflation	4%/yr.
• Additional construction cost escalation	1.0%/yr.
• Additional fuel oil price escalation	2.2%/yr.
• Additional coal price escalation	-0.7%/yr.
• Additional electric power price escalation	2.3%/yr.
• IUS Plant Life	25 years

Unless otherwise stated, all costs and savings are in dollars brought forward to 1981 using the above

assumptions or brought back to 1981 using the state of Florida bond interest rate of 6.5% as a discount rate.

The decision making risk for proceeding now in an IUS investment program is clearly associated with error in judgement of what will happen in the future. The team used two prime economic indicators to evaluate the alternatives considered: Interest Rate of Return on the Investment, and Payback Time.

The question is posed: How sensitive are the conclusions and the recommendation to variations in the input data? The changes in payback period and interest rate of return on the investment were tested in a series of sensitivity analyses. The following observations can be made with respect to the recommendation:

1) The results are relatively insensitive to an error of 20% plus or minus in the capital cost estimate.

2) A change in the discount rate from 6.5% to 5.5% or 7.5% had little effect because of the rapid payback period and the low discount rate used.

3) Since the additional operation and maintenance costs are a small fraction of total annual costs, errors of plus or minus 20% have little effect on the economic benefits.

4) Variations in the economic life of the plant of plus or minus 5 years have negligible effect.

5) An increase of plus one-half or a decrease of one-half of the assumed rate of inflation of 4% per year will add or deduct only 2 percentage points to the indicated interest rate of return on the investment.

6) A 20% variation in the price of either coal or oil would increase or decrease the interest rate of return by slightly more than a tenth. As oil prices increase the coal fired plant would look more attractive. Within the range of coal price fluctuations tested the economic indicators are excellent.

7) A general reduction in the escalation of energy costs including purchased electricity to the projected general rate of inflation of 4% would make the indicators less attractive. However, the interest rate of return would still exceed 18% and the payback period would not exceed 5 years.

8) The "base case" against which the comparisons are made assumes the existing plant would be burning oil in 1981. If in fact gas is available and is burned either 1/3 or 2/3 of the time, the indices are unfavorably effected. However, the interest rate of return still exceeds 20% and the payback period does not exceed 6 years.

The penalty for inaction is dramatized in Figure 1. Energy costs for the University are estimated to be $9 million per year by 1981. If the IUS goes on stream then those costs are estimated to drop 44% per year. (If the general inflation and fuel escalation is higher than assumed then cost savings will be higher than predicted and the penalty for inaction will be higher.) Thereafter the existing system cost performance follows the top curve and the IUS system performance would follow the bottom curve.

F SCHEDULE FOR CONSTRUCTION

The schedule for construction and major equipment purchases for the recommended option - 12.5 megawatt electric plant and a 25 or 75 tons per day solid waste incineration plant is presented in Figure 2. Note that the overall schedule is estimated at 42 months.

In order to relate the budgeting and fiscal material in Tables 1 through 4 to the construction schedule in Figure 2, the reader is reminded that the recommendation is to proceed now to budget, design and install an IUS for start-up in 1981. Presuming that the University and the State accept the recommendation, the balance of calendar year 1976 and the first quarter of 1977 should be devoted to University and State review, seeking approval of the capital outlay program, and initiating the design and construction contracting process.

RECOMMENDED OPTION

12.5 MW Thermal Electric Generation System with either of two levels of solid waste incineration
25 Tons of solid waste per day (University only), or 75 tons per day (University and Commercial Community)

All Dollars (000)		Base Case as Basis for Comparison (1)	12.5 MW + Absorption (2) Cooling + LTHW (3)	University Solid Waste Incineration (25 Tons/Day)	Total	University and Commercial Community Solid Waste Incineration (75 Tons/Day)	Total
Capital Cost Required to Plant Start-up (1976 Dollars)		--	14,745	591	15,336	1,691	16,436
Capital Cost Inflated to Projected Date of Disbursement.	FY-1977	--	--	--	--	--	--
	FY-1978	--	2,988	--	2,988	--	2,988
	FY-1979	--	4,898	--	4,898	--	4,898
	FY-1980	--	7,005		7,005		7,005
	FY-1981	--	2,550	729	3,279	2,066	4,616
	FY-1986	1158 (4)	--	11 (5)	11	23 (5)	23
	FY-1991	1416 (4)	--	14 (5)	14	29 (5)	29
	FY-1996	--	--	1042 (6)	1,942	3120 (6)	3,120
Cumulative Total of Expended Capital Funds at Plant Start-up in 1981		--	17,441	729	18,177	2,066	19,547
Capital Cost Required to Plant Start-Up (inflated to 1981 dollars).		--	19,789	729	20,549	2,066	21,963
Annual Operating Cost (1981 dollars).		10,017 (7)	5,967	-183	5,784	-333	5,634
Annual Operating Cost Savings Over Base Case (1981 dollars)		--	4,050	183 (8)	4,233	333 (8)	4,383
Present Worth of Net Savings (9) (1981 dollars)		--	71,047	--	73,423	--	73,895
Savings to Investment Ratio (10)		--	3.93	--	3.8	--	3.4
Interest Rate of Return (%) (11)		--	23.3	--	23.4	--	22.9
Payback Time (Years) Including Interest on Capital (12)		--	4.7	--	4.7	--	4.8

1. The base case is the existing system with fuel oil as the principle fuel.
2. It is assumed that 5,900 tons of the on-going air conditioning system expansion program will be procured with absorption chillers rather than electric motor driven chillers as originally planned.
3. A small capital cost is included in this project to convert the steam distribution line between the steam plant and the medical center to low temperature hot water (LTHW).
4. Replace existing boiler.
5. In plant rolling stock replacement.
6. Major plant replacement.
7. Including solid waste disposal costs.
8. Compared to existing disposal costs.
9. Present value of net savings minus present value of invested capital and interest((1981 point of reference).
10. Present value of incremental savings divided by incremental investment required (1981 point of reference).
11. Discount rate for which payout time equals project operating life (25 years).
12. Time required to recover the initial investment. Expended dollars, including interest on capital, divided by net annual savings in 1981 constant dollars.

TABLE 1

12.5 M.W. THERMAL ELECTRIC GENERATION SYSTEM

WITH INCINERATION OF UNIVERSITY SOLID WASTE (25 TONS/DAY)

Cost Disbursements by Fiscal Year

Based on Plant Start-Up in 1981

Cost Breakdown by Category	Estimated Commitment Date	Disbursements (000) by Fiscal Year				Total
		FY 1978	FY 1979	FY 1980	FY 1981	
Engineering and Fees	Sept. 1977	818	273	109	164	1,364
Turbine Generator	March 1978	208	832	1,976	451	3,467
Steam Generation including Pollution Control	April 1978	1,159	1,626	1,388	464	4,637
General Construction	Nov. 1978	803	2,167	3,532	1,525	8,027
Solid Waste Energy Recovery	Oct. 1980	0	0	0	675	675
Total		2,988	4,898	7,005	3,279	18,170

TABLE 2

12.5 M.W. THERMAL ELECTRIC GENERATION SYSTEM

WITH UNIVERSITY AND COMMERCIAL COMMUNITY

SOLID WASTE INCINERATION (75 TONS/DAY)

Cost Disbursement by Fiscal Year

Based on Plant Start-Up in 1981

Cost Breakdown by Category	Estimated Commitment Date	Disbursements (000) by Fiscal Year				Total
		FY 1978	FY 1979	FY 1980	FY 1981	
Engineering and Fees	Sept. 1977	818	273	109	263	1,463
Turbine Generator	March 1978	208	832	1,976	451	3,467
Steam Generation including Pollution Control	April 1978	1,159	1,626	1,388	464	4,637
General Construction	Nov. 1978	803	2,167	3,532	1,525	8,027
Solid Waste Energy Recovery	Oct. 1980	0	0	0	1,913	1,913
Total		2,988	4,898	7,005	4,616	19,907

TABLE 3

IUS TWO PHASE INCREMENTATION WITH COST DISBURSEMENTS
BY FISCAL YEAR BASED ON PHASE I PLANT START-UP IN 1981

PHASE I - 6.25 M.W. THERMAL ELECTRIC GENERATION SYSTEM
WITH UNIVERSITY SOLID WASTE INCINERATION (25 TONS/DAY)

Cost Breakdown by Category	Estimated Commitment Date	Disbursements (000) by Fiscal Year					Total
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	
Engineering and Fees	Sept. 1977	474	153	85	71	0	783
Turbine Generator	March 1978	112	447	1,062	242	0	1,863
Steam Generation including Pollution Control	April 1978	594	813	731	238	0	2,376
General Construction	Oct. 1978	253	829	2,870	927	0	4,879
Solid Waste Energy Recovery	Oct. 1980	0	0	0	675	0	675
Sub Total		1,433	2,242	4,748	2,153	0	10,576

PHASE II - 6.25 M.W. THERMAL ELECTRIC GENERATION SYSTEM
WITH COMMERCIAL COMMUNITY SOLID WASTE INCINERATION (50 TONS/DAY)

Engineering and Fees	Sept. 1978	0	383	118	111	95	707
Turbine Generator	March 1979	0	101	406	963	220	1,690
Steam Generation including Pollution Control	April 1979	0	574	880	671	239	2,364
General Construction	Oct. 1979	0	210	559	1,434	1,085	3,288
Solid Waste Energy Recovery	Oct. 1981	0	0	0	0	1,306	1,306
Sub Total		0	1,268	1,963	3,179	2,945	9,355
PHASE I & II TOTAL		1,433	3,510	6,711	5,332	2,945	19,931

TABLE 4

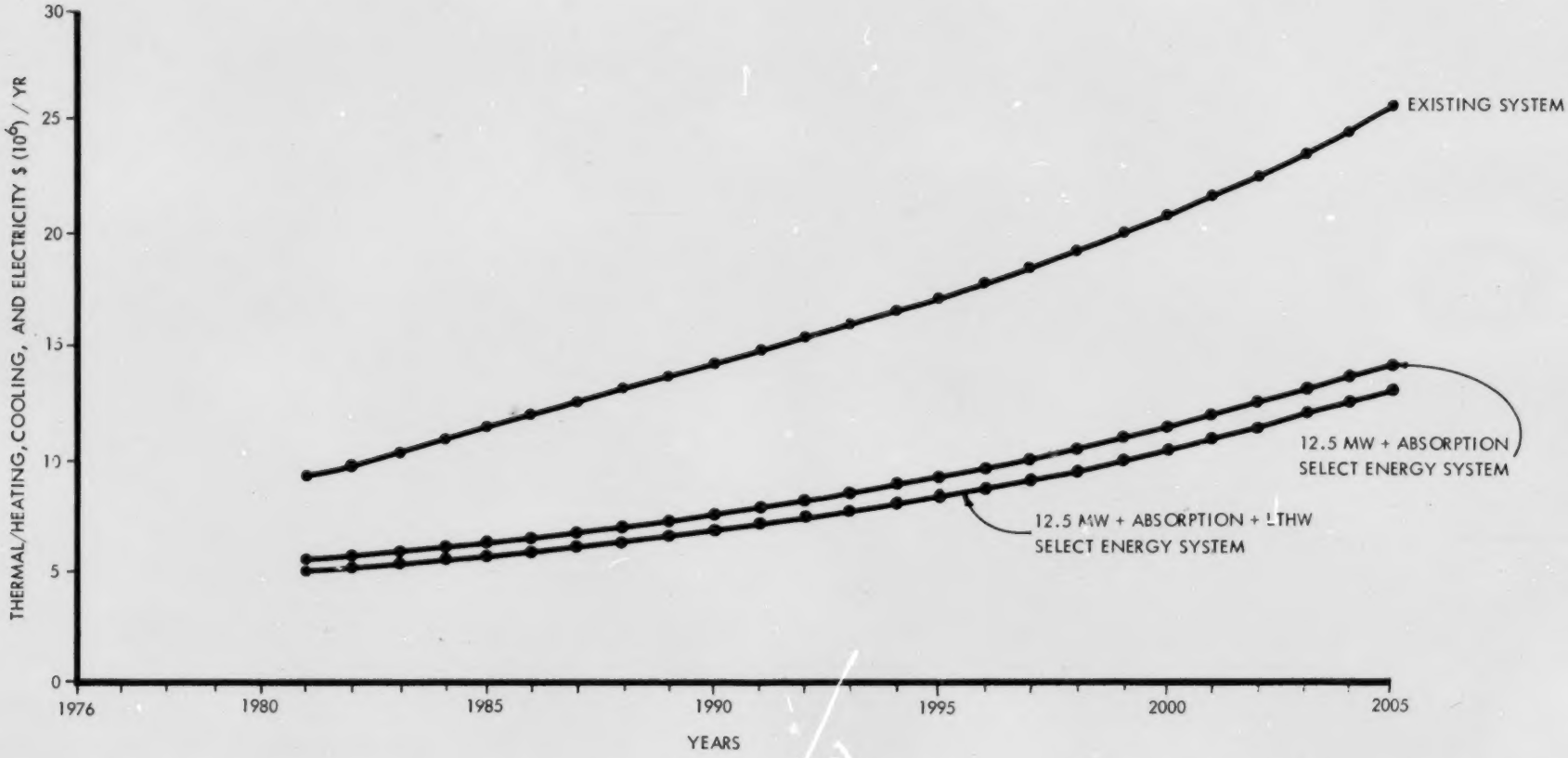

FIGURE 1

PROJECTED UNIVERSITY OF FLORIDA UTILITY COST

SCHEDULE FOR CONSTRUCTION OF INTEGRATED UTILITY SYSTEM AT UNIVERSITY OF FLORIDA

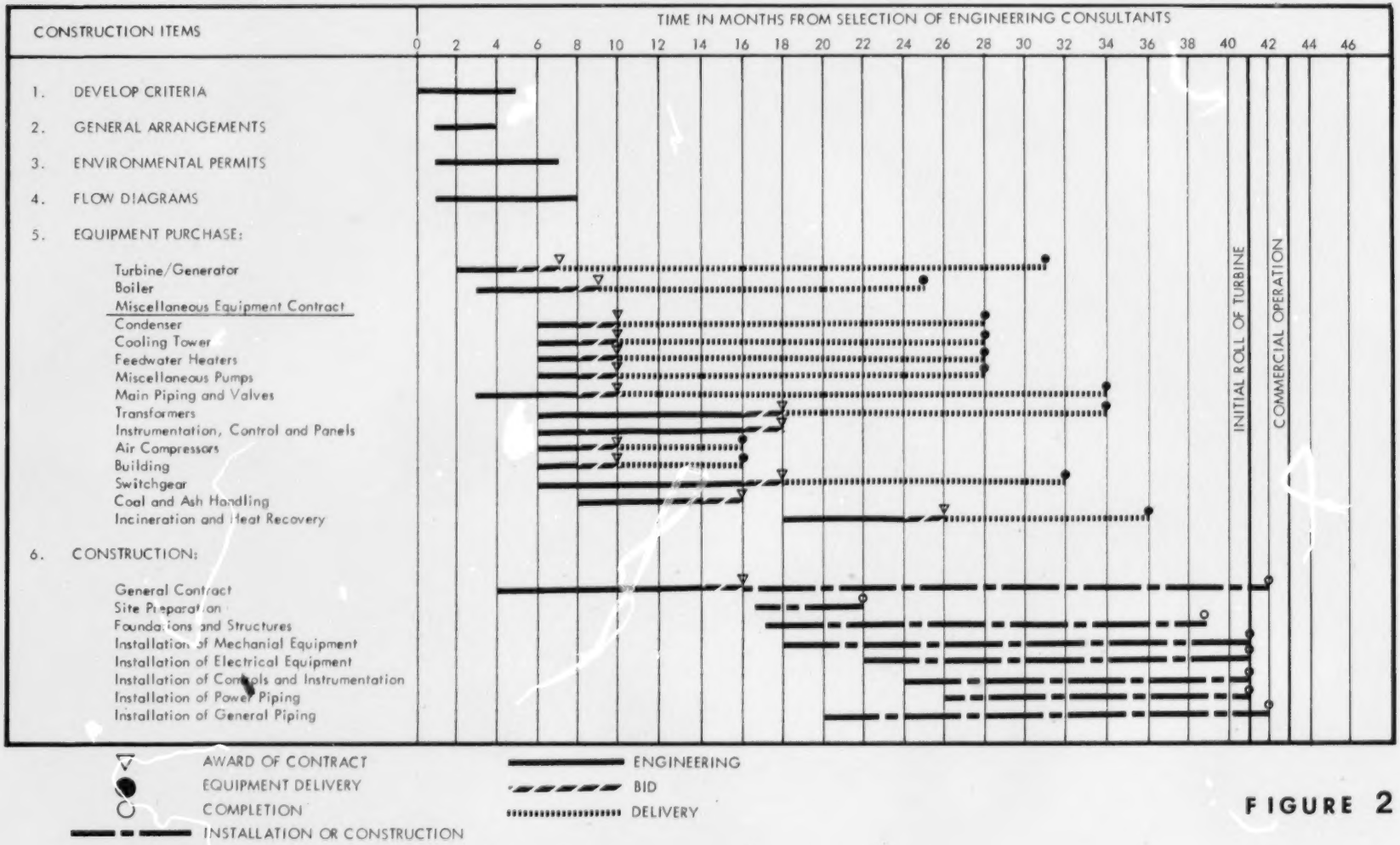

FIGURE 2